Early Exposure to Environmental Chaos and Children's Physical and Mental Health

Abstract

Environmental chaos has been proposed as a primary mechanism through which poverty negatively affects children's health and development, with the potential for particularly pernicious effects during the earliest years when children are most susceptible to environmental insults. This study employed a within-group approach, assessing 495 young children from low-income families living in concentrated poverty urban neighborhoods. Following children from infancy through early childhood, multilevel models assessed the roles of environmental disorder (from housing and neighborhood contexts) and instability (from residential and relational shifts) in predicting child functioning at age 2½ and age 6. Results revealed that environmental disorder during infancy predicted heightened developmental delays at age 2½ and poor health at age 7. Both environmental disorder and environmental instability in childhood were predictive of children's behavior problems at age 7. Findings highlight the unique roles of the domains, timing, and intensity of environmental chaos in inhibiting young children's healthy development.

Keywords: Environmental Chaos; Instability; Disorder; Mental Health; Physical Health; Low-Income Families; Poverty

Introduction

In recent years American families have experienced growing economic instability, heightened volatility in the housing market, and greater flux and diversity in family relationships. For children and families, these forces translate into more chaos and uncertainty in their day-to-day lives with decreasing stability in families and households and increasing disorder in homes and communities (Annie E. Casey Foundation, 2011). These stressors, which are often conceptualized in the literature as environmental chaos (Bronfenbrenner & Evans, 2000), confer strain on children and parents and undermine healthy family functioning (Deater-Deckard et al., 2009; Evans, Boxhill, & Pinkava, 2008). Numerous studies investigating links between environmental chaos and children's functioning have found that chaotic experiences impede children's physical, socio-emotional, and cognitive well-being (Coldwell, Pike & Dunn, 2006; Evans et al., 2005; Vernon-Feagans, Garrett-Peters, Willoughby, Mills-Koonce, & The Family Life Project Key Investigators, 2012). Research finds that experiences of environmental chaos are especially common among low-income families, with economic, housing, and relational insecurities both contributing to and being affected by poverty (Deater-Deckard et al., 2009; Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005).

Although there is a large body of literature linking chaotic experiences to negative outcomes for children, our current understanding of the role of chaos in children's lives is constrained by a lack of conceptual and operational clarity regarding the definition of chaos. There also remain questions regarding when, for whom, and under what conditions environmental chaos is most detrimental to children's healthy development. Extant research has typically focused on just one component of chaos at a time and has often measured chaos in one context (e.g., family), ignoring other proximal contexts (e.g., households and neighborhoods).

The intensity and developmental timing of environmental chaos also has not received systematic attention.

In this research we draw on Shonkoff's (2010; Shonkoff & Garner, 2012) ecobiodevelopmental theory on the far-reaching developmental implications of early pernicious environmental experiences to address a richer conceptualization of environmental chaos. The ecobiodevelopmental theory has four key components regarding the domains, timing, intensity, and biological vulnerability related to environmental chaos. First, it delineates different domains of environmental chaos including environmental instability (the consistency and stability of primary relationships and contexts) and environmental disorder (the safety and support of proximal contexts). Second, this theory contends that the developmental timing of chaotic experiences is influential, with infancy representing an exceptionally sensitive period of development during which children experience rapid neurological and biological changes, leaving them particularly vulnerable to environmental insults. As such, this model purports that environmental chaos experienced early in life will have more harmful effects than chaos experienced later. Third, this model argues that adverse environmental experiences that are recurring, prolonged, and extensive are more detrimental to children's health and well-being than unfavorable experiences that are targeted and short-term, suggesting that the intensity or duration of environmental chaos is important. Finally, drawing on a long history of developmental theory (Bronfenbrenner & Morris, 1998), the model argues that environmental chaos is likely to interact with biological vulnerabilities to affect development.

Following the ecobiodevelopmental model (Shonkoff, 2010; Shonkoff & Garner, 2012), the current analysis explores (1) whether distinct domains of chaotic experiences (environmental instability and environmental disorder) have unique associations with children's development,

focusing specifically on children's physical and mental health; (2) whether early childhood environmental chaos is more strongly predictive of children's physical and mental health than later environmental chaos; (3) whether the intensity of environmental chaos is associated with children's outcomes; and (4) whether biological vulnerabilities interact with environmental chaos to predict developmental outcomes.

Conceptualizing and Operationalizing Environmental Chaos

A growing line of research has fostered the development of the "chaotic systems" framework (Bronfenbrenner & Evans, 2000; Evans & Kim, 2013; Shonkoff, 2010; Shonkoff & Gardner, 2012), which argues that for some children, their family, household, and community contexts are characterized by unpredictability, inconsistency, and lack of regularity. Experiences of chaos are especially common among low-income families, with research suggesting that family and community poverty are primary correlates of chaos and inconsistency in children's proximal environments (Newman, 2008; Evans et al., 2005; Evans & Kantrowitz, 2002; Shonkoff, 2010). The ecobiodevelopmental model (Shonkoff, 2010; Shonkoff & Garner, 2012) suggests that chaos can be conceptualized in terms of two domains – environmental instability and environmental disorder. Environmental instability refers not only to changes in residence but also changes in household composition – such as parental figures and other adults moving in and out of the home. Environmental disorder is used to describe the quality of the physical setting of the home and neighborhood including characteristics such as noise, disrepair, cleanliness, crowding, and safety.

A expanse of empirical research has employed a diversity of approaches for operationalizing chaos ranging from broad composite measures of household chaos to narrow conceptualizations focusing on a specific arena. For example, a number of studies have used

multi-item composite measures such the Confusion, Hubbub, and Order Scale (Matheny, Wachs, Ludwig, & Phillips, 1995) which captures in-home family processes like "being able to hear yourself think in our home" and "usually able to stay on top of things." Studies employing this scale have linked higher levels of household disorder with children's heightened behavior problems (Coldwell et al., 2006), lower IQ (Deater-Deckard et al., 2009), and lower early literacy skills (Johnson, Martin, Brooks-Gunn & Petrill, 2008). Other composite measures of chaos that broadly capture household disorder through a lack of organization and presence of ambient noise, such as living in homes where the television is generally on, have been linked with aggressive behaviors and attention problems (Martin et al., 2012), and inhibited language development (Martin et al., 2012; Vernon-Fagan et al., 2012) among young children, as well as heightened psychological distress in youth (Evans et al., 2005).

Other studies have focused on more distinct aspects of environmental disorder and instability, such as unsafe housing conditions, maintenance deficiencies, pollution, and neighborhood crime (Evans & Kim, 2012; 2013; Roche & Leventhal, 2009; Schofield et al., 2012; Vernon-Feagan et al., 2012). This work supports the importance of safety and comfort at both household and neighborhood levels. A recent study of low-income urban families, for example, identified structural and maintenance deficiencies (i.e., lack of heat and light, presence of rodents and peeling paint) as the most potent housing feature associated with children's emotional and behavioral problems (Coley et al., 2012). Similarly, higher levels of neighborhood crime and social disorder have been associated with less advanced behavioral and cognitive skills among children (Leventhal & Brooks-Gunn, 2000, 2004; McWayne, McDermott, Fantuzzo, and Culhane 2007). A limitation of past research has been the tendency to treat household and neighborhood disorder as distinct constructs, ignoring the embedded nature of the

two. As one exception, one recent study using a person-oriented modeling strategy found that housing and neighborhood disorder clustered together into distinct patterns among low-income families (Coley, Kull, Leventhal, & Lynch, 2013), and the cluster with the highest level of housing deficiencies and neighborhood disorder was associated with the most elevated levels of emotional and behavioral problems among preschool through adolescent-aged children. These results point to the importance of considering both household level and neighborhood level disorder in a comprehensive fashion.

Similarly, little research has considered broader conceptualizations of environmental instability, with extant work tending to separate family instability from residential instability. Numerous studies have found associations between maternal relationship instability and young children's behavior problems in both low-income and economically diverse samples of families (Ackerman et al, 1999; 2002; Cavanagh & Huston 2006; Fomby & Cherlin 2007; Magnuson & Berger 2009; Osborne & McLanahan 2007), with some studies also showing links to emotional problems (Bachman, Coley, & Carrano, 2011). Research on young children's residential instability has delineated associations with worse physical health outcomes (Busaker & Kasehagen, 2012; Cutts et al., 2011; Kamp Dush, Schmeer, & Taylor, 2013) as well as heightened emotional and behavioral problems (Coley, et al., 2012; Ziol-Guest & McKenna, 2013). Little research has assessed instability in a more comprehensive fashion by addressing both relational and residential changes. This is surprising given research identifying positive associations between mothers' marital transitions and rates of residential mobility over time (Kull, Coley, & Lynch, 2013).

Together, recent research considering a broad range of environmental chaos factors has shown empirical support for the importance of household and neighborhood disorder as well as

residential and relational instability, but little work has clustered these categories into broader thematic chaos constructs as suggested by the ecobiodevelopmental model. As an important exception, in a study of low-income rural children from birth to age three, Vernon-Feagans and colleagues (2012) factor analyzed a broad range of environmental chaos measures, delineating one domain describing physical disorder and disorganization within the household and neighborhood (e.g., the presence of ambient household and neighborhood noise, crowded and unclean housing) and a second domain capturing instability in residence and family composition (residential moves, primary and secondary caregiver changes). This work found that environmental disorder but not instability was predictive of young children's language skills, but did not consider other important arenas of child functioning such as physical and mental health.

Developmental Timing of Environmental Chaos

In addition to arguing for the importance of the two domains of environmental disorder and instability for children's development, the ecobiodevelopmental model further suggests that the timing of exposure to such contexts is critical. Due to young children's immature physiological and psychological resources, Shonkoff (2010; Shonkoff & Garner, 2012) argues that experiences of adversity and environmental chaos early in life have the capacity to disrupt the processes involved in the development of children's stress reactivity, neural circuitry, physiological regulation, as well as metabolic, cardiovascular, and immunological systems, in turn impacting short and long-term health and development (Blair, 2002; Blair, Raver, Granger, Mills-Koonce, Hibel, & The Family Life Project Key Investigators, 2011; Meaney, 2010; Shonkoff & Garner, 2012). Evans and colleagues have been instrumental in identifying such associations in school-aged and adolescent youth, with results showing that experiences of household disorder are associated with poorer socio-emotional functioning in the domains of

learned helplessness, self-regulatory behavior, and psychological distress (Evans, Saltzman, & Cooperman, 2001; Evans et al., 2005). However, there is little work that examines the effects of chaos among very young children or considers whether chaos experienced at an earlier age may be more detrimental than chaos experienced later in childhood. Research on household disorder and residential instability among children aged 2 through 20 found no systematic evidence of developmental differences in associations with emotional and behavioral functioning (Coley et al., 2012), although this study did not include infants. In the realm of family structure instability, some research has tried to distinguish effects of early childhood versus later childhood instability, with no replicated patterns emerging (Bachman et al., 2011; Fomby & Cherlin, 2007). Thus, more attention is needed to delineating the role of both disorder and instability during infancy versus later in childhood on children's healthy development.

Additional Limitations in Prior Work: Intensity and Biological Vulnerabilities

Another limitation in the measurement of environmental chaos in prior literature is the lack of attention to the intensity of chaos. For some children and families, experiences of chaos are temporary and short-lived. However, for many children, high rates of environmental disorder and frequent environmental instability may be constant over a period of years. According to ecobiodevelopmental theory (Shonkoff, 2010; Shonkoff & Garner, 2012), the intensity duration of chaos is important, and yet most past research measures environmental chaos at one point in time as a simple linear construct, lacking measurement or analytic techniques to delineate nonlinearities in associations between chaos and children's health and development.

In addition, little attention has been paid to the potential for interactive effects between environmental chaos and children's biological predispositions, reflecting the fourth hypothesis generated by the ecobiodevelopmental theory (Shonkoff, 2010; Shonkoff & Garner, 2012).

Children with a biological vulnerability may be influenced most strongly by inconsistent and disordered environments, lacking the regulatory skills to self-sooth or garner caregiver resources (Ackerman et al., 1999). For example, low birth weight is a long-established biological indicator of heightened susceptibility to environmental influences (Escalona, 1982; Kalmar & Boronkai, 1991; Shonkoff, Boyce & McEwan, 2009). The more limited consistency in proximal caregivers and environments driven by environmental instability and the less supportive and more distracting environments derived through environmental disorder may interact with low birth weight children's less mature resources to predict physical and mental health outcomes.

Present Study

In summary, theory and research argue that early childhood environmental chaos can permeate multiple ecologies of children's lives with negative implications across a range of physical and mental health indicators. Although the evidence base is growing regarding the role of chaos in children's lives, extant research has paid less attention to these processes for infants or for children with biological vulnerabilities, who may have a heightened susceptibility to stressful experiences (Blair et al., 2011; Evans & Kim, 2013). Hence, it is important to investigate the multiple domains in which chaos is present for young children and the short- and longer-term associations between widespread environmental chaos and children's physical and mental health. The present study addresses these issues in a sample of low-income urban families by examining the associations between two domains of chaos and child functioning across a six-year period, attending to the domains, timing, and intensity of environmental chaos and to potential interactions with children's biological predispositions as assessed through low birth weight. In contrast to much past research, which has highlighted the frequency with which chaotic conditions are observed among children from low-income families when compared to

their peers from middle- and upper-income families (Evans, 2004; Evans et al., 2005; Evans & Kantrowitz, 2002), this study takes a within-group approach to more carefully attend to the notable variation in environmental contexts within samples of low-income families (Vernon-Feagans et al., 2012).

Method

Participants

Data for this study were drawn from the *Three City Study*, a longitudinal, multi-method study of low-income children and families living in moderate to high poverty neighborhoods in Boston, Chicago and San Antonio (Winston et al., 1999). A stratified random sampling procedure selected families with incomes below 200% of the poverty line, a child between the ages of 0 to 4 or 10 to 14 years, and a primary female caregiver. The screening response rate was 90%, with an interview rate of approximately 83%, leading to a 74% response rate for the first wave of data collection in 1999 and a sample size of approximately 2,400 families. Families were re-interviewed 1½ years later in 2001 (88% retention rate of wave 1) and 4½ years after that, in 2005-2006 (80% retention rate of wave 1). At each wave, primary caregivers (over 90% of whom were biological mothers of the focal child) participated in 2-hour face-to-face surveys in English or Spanish, children were directly assessed, and older children participated in interviews. The analytic sample for this study included families with focal children who were less than 2 years old at the first wave of data collection (N = 495) in order to focus on infant environmental contexts. Focal children averaged 12 months of age in wave 1, 2 ½ years in wave 2, and 6 years in wave 3.

Measures

Child outcomes. Children's developmental delays and general health were assessed at wave 2. At wave 3, the study assessed general health and added additional developmentally appropriate measures of emotional and behavioral problems.

Developmental delays were measured using mother-report and interviewer assessments from the Ages and Stages Questionnaire (ASQ; Squires, Potter & Bricker, 1999) at the second wave of data collection. The ASQ assessed children's functioning in the domains of communication, problem-solving, fine-motor skills, gross-motor skills, and personality-social development. An indicator variable delineated the likelihood of delayed development in each of the five domains, and these indicators were summed to create a count of the number domains of delay for each child. Children's *poor health* was reported by mothers at waves 2 and 3 with a single item assessing the child's general health status, coded such that higher scores indicate poor health (1 = *very good* to 5 = *poor*).

Behavioral, emotional, and total problems were measured at wave 3 using the well-validated mother-reported Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001). Broadband standardized scores were computed for each child to assess externalizing behavior problems, capturing aggressive and rule-breaking behaviors ($\alpha = 0.90$), internalizing emotional problems, capturing anxiety, depression, withdrawal, and somatization ($\alpha = 0.87$), and total problems, which include the previous domains as well as social, thought, attention, and other aspects of problem behaviors ($\alpha = 0.95$).

Environmental chaos. Chaos was assessed across the domains of environmental disorder and instability, with parallel measures used at all three waves of the survey. The domain of environmental disorder included housing and neighborhood disorder. *Housing disorder* was assessed using a count of mother-reported and interviewer-observed structural and

safety concerns. Eight mother-report eight items captured issues like broken windows, exposed wires, peeling paint, and rodents. Four interviewer-observed items (drawn from the Home Observation for Measure of the Environment-Short Form, Bradley & Caldwell, 1979) delineated presence of unsafe or unlit characteristics of the unit and building. Each item designated the presence or absence of the housing problem, and items were summed to a total count (Coley et al., 2012). *Neighborhood disorder* was assessed using seven mother-report items drawn from Elliott and colleagues (1996) that capture the severity of neighborhood crime and social disorder like abandoned houses and burglaries, assaults, and drug dealing (1 = *not a problem*; 2 = *somewhat of a problem*; 3 = *a big problem*). Items were averaged to create a continuous variable of neighborhood disorder ($\alpha_{1\text{-}3}$ = 0.86 - 0.89).

Family instability was captured using reports of residential instability and maternal relationship transitions. *Residential instability* was reported by mothers and coded as a count indicating how many times the family had moved between study waves (starting from the child's birth for wave 1). *Relationship instability* was reported by mothers in a relationship history module of the survey that was administered at wave 3. Using a calendar, mothers recounted the start and end dates of all co-residential relationships including marriages and non-marital cohabitations that lasted at least one month. From these data, counts of the number of mothers' relationship transitions between survey waves were computed (from the child's birth for wave 1); these counts included both entrances into and exits from cohabitations and marriages (Bachman et al., 2012).

These individual measures were then combined into broader composites for analyses. At each wave, composite measures of environmental chaos were created by standardizing and averaging the housing and neighborhood disorder variables. Similarly, an environmental

instability composite was created at each wave by summing the residential and relational instability count variables. These composites, which we term infant, early childhood, and middle childhood disorder and instability, were used to assess the domain and developmental timing roles of environmental chaos. To assess intensity, each of the four individual environmental measures at each wave was coded into a dichotomous variable, with a score of 1 for levels equal to or greater than 1 standard deviation about the sample mean and 0 otherwise. The dichotomized variables for household and environmental disorder were summed over the waves into a score of cumulative disorder; similarly, the dichotomized variables for relational and residential instability were summed over the waves into a score of cumulative instability.

Covariates. A number of child, mother, family, and community variables that have been linked with the primary variables of interest and children's development were included in analyses to decrease concerns over omitted variable bias. All covariates were drawn from wave 1. Child age was coded in months and child gender was coded 1 = *male* and 0 = *female.* An indicator designated whether children were born low birth weight (< 2500 grams). Race/ethnicity was designated as White/other, African American (omitted), or Hispanic. Mother's marital status was coded as married, cohabiting, or single (omitted). Mothers' educational attainment was coded categorically as less than high school, a high school degree or GED (omitted), or college/technical training. Indicators assessed mother's employment status and receipt of TANF. Family income was assessed through an income-to-needs ratio, comparing the total household income from all sources to the federal poverty standards adjusting for family size. Each family's city of residence was designated to adjust for macroeconomic and policy differences across locations.

Analytic Approach

Analyses employed multilevel regression models to test associations between environmental chaos and children's physical and psychological health. Multilevel models (with children nested within cities) were used to address the clustering of children within the three cities with random effects for city. Three sets of models were run. To focus on the domain and timing of environmental chaos, the first set of models predicted children's developmental delays and poor health at wave 2 (age 2½ years) with the infant and early childhood disorder and instability variables; similarly, models predicted children's physical health and behavioral, emotional, and total problems at wave 3 (age 6 years) with the disorder and instability variables from infancy, early childhood, and middle childhood. Bivariate correlations between the environmental chaos variables were small to moderate, ranging from -.02 to .24, supporting the decision to model these as distinct constructs. The second set of analyses assessed the intensity of environmental chaos using the cumulative disorder and instability measures to predict child functioning at wave 2 and wave 3. For models predicting wave 2 outcomes, the intensity scores from waves 1 and 2 were summed; for models predicting wave 3 outcomes, all three waves of intensity scores were incorporated. Finally, the third set of analyses replicated sets one and two including interactions between the disorder and instability variables and child low birth weight. All models included the full set of covariates noted above to help isolate unique associations between our primary measures of disorder and instability and children's functioning and incorporated probability weights that adjust for the sampling frame and differential response, thereby making the sample representative of low-income mothers and young children living in low-income neighborhoods in Boston, Chicago, and San Antonio.

Prior to conducting analyses we explored the presence of missing data due to attrition and item nonresponse, which was moderate and indicated that data were missing at random,

supporting the appropriateness of imputing missing data to decrease concerns over sample bias. Multiple imputation using a bootstrap-based Expectation Maximization Bayesian (EMB) algorithm (Honaker & King, 2010) was conducted in R to create 30 complete data sets.

Results

Descriptive Results

The analytical sample used in the current study included 495 infants who were 24 months or younger at the wave 1 survey administration. Table 1 presents descriptive data on the sample. At wave 1, the infants were on average 12.7 months old, 48% were male, and 6% had been classified as low birth weight. Also at wave 1, 53% of mothers were Hispanic, 41% African American, and 6% were White/other. Thirty-seven percent of mothers had completed some education beyond high school. In regard to financial well-being, 38% of mothers were employed, 40% were receiving TANF assistance, and most families were poor, with an average income to needs ratio of 0.85. Families were equally divided among Boston, Chicago, and San Antonio.

Domains and Developmental Timing of Environmental Chaos

Results from the first set of multilevel regression models, which explored the relationship between the domains (disorder and instability) and developmental timing (infancy, early childhood, and middle childhood) of chaos and child outcomes, are presented in the top panel of Table 2. Results from these models suggest that chaos during infancy and early childhood was not associated with early childhood functioning in terms of either physical health or developmental delays measured at age 2½. Turning to child functioning at age 6, significant results emerged, concentrated among middle childhood disorder and instability. Specifically, only one significant coefficient is seen among the measures of infant and early childhood

disorder and instability. Higher levels of infant disorder predicted poorer health in middle childhood, with a small effect size of 0.11 standard deviation (SD) unit changes in health per SD change in disorder. Alternately, chaos during middle childhood was a more consistent predictor of child functioning, with environmental disorder predicting increases in both internalizing (0.18 SD) and total problem (0.19 SD) scores as well as similarly-sized but only marginally significant increases in externalizing problems (0.15 SD). In addition, environmental instability predicted increases in both externalizing (0.15 SD) and total problem scores (0.11 SD).

Intensity of Environmental Chaos

The next set of models, presented in the top panel of Table 3, assessed the cumulative scores of disorder and instability to test whether consistent and sustained chaos over time was related to child functioning. Results suggested that sustained environmental disorder experienced through infancy and early childhood was related to increases in developmental delays, with an effect size of 0.39 SD. Similarly, cumulative environmental disorder during infancy, early, and middle childhood was related to poorer health (0.17 SD), increases in externalizing problems (0.12 SD), and marginally significant increases in total problems (0.15 SD) in middle childhood. In contrast, no significant associations emerged between the intensity of instability and children's physical and mental health in early and middle childhood, although marginally significant and small associations emerged with externalizing (0.14 SD) and total (0.14 SD) problems.

Early Biological Vulnerability as a Moderator of Environmental Chaos

Our final regression models considered whether early biological vulnerabilities may moderate the relationship between environmental chaos and child functioning. To test this idea, we added interactions between low birth weight status (i.e., weighing less than 2500 grams at

birth) and our environmental chaos constructs. Results, presented in the bottom panels of Tables 2 and 3, generally show null effects. Only one significant interaction emerged (), and this interaction ran counter to expectations, with early childhood instability more positively associated with developmental delays for children born at normal rather than low birth weight.

Discussion

Recent years have brought notably increased insecurity in many realms of family life, including economic resources, housing and community contexts, and family relationships (Annie E. Casey Foundation, 2011). Concurrently, theoretical and empirical research has made inroads in delineating how broader contextual forces translate into environmental chaos at a proximal level, which can affect healthy growth and development across many domains (Bronfenbrenner & Evans, 2000; Shonkoff, 2010; Shonkoff & Garner, 2012). These two shifts heighten the need to further our understanding of the role of environmental chaos in economically disadvantaged families and communities, and to more carefully delineate associations with children's development. Based upon Shonkoff's ecobiodevelopmental model (2010; Shonkoff & Garner, 2012) of the developmental implications of early environmental chaos and employing a within-group approach focused exclusively on low-income children in high poverty urban neighborhoods, this study added to the extant literature base in three key realms.

An Expanded Definition of Chaos

Following the ecobiodevelopmental model as well as prior empirical evidence from Vernon-Fagan and colleagues (2012), this study conceptualized environmental chaos as transpiring within the two broad domains of environmental disorder and environmental instability. Expanding most prior research that has used more focused, topical measures of chaos, we captured multiple levels of each domain, assessing disorder through both structural

and maintenance deficiencies in proximal home contexts and greater crime, danger, and social dislocation in more distal neighborhood contexts, and assessing instability in terms of both where and with whom children live. Results from this study provide evidence for the importance of both disorder and instability, although disorder was somewhat more consistently associated with children's physical and mental health than instability. Specifically, heightened levels of environmental disorder predicted modest increases in both poor physical health and developmental delays as well as in children's emotional and behavioral problems; in contrast, heightened environmental instability was associated solely with children's behavioral functioning and not with health or developmental delay outcomes. These findings replicate and extend other recent research which has highlighted the role of housing and neighborhood disorder in children's functioning (e.g., Coley et al., 2012; 2013; Evans et al., 2005), finding stronger associations for disorder than for instability in predicting children's functioning across various domains (Coley et al., 2012; Vernon-Feagans et al., 2012).

In examining the differences between the effects of disorder and instability, it is important to consider how these contextual forces may translate into proximal processes influencing children's health and development. Central processes for infants and young children revolve around the consistency, responsivity, and stimulation provided by their primary caregivers. Indeed, research and theory argue that such processes are central mechanisms through which environmental chaos affects children's health and functioning (Bronfenbrenner & Evans, 2000; Deater-Deckard et al., 2009; Evans & Kim, 2013). Finding stronger associations between environmental disorder and children's functioning than between environmental instability and children's functioning suggests that family processes may respond differently to these two arenas of environmental chaos. It is possible that low-income mothers are better able to

protect their children against potential effects of residential and relational instability, retaining consistency and responsivity in their parenting processes and hence leading to more limited child effects. In contrast, housing and neighborhood disorder may have a stronger influence on parents, disrupting their own psychological and physiological functioning. Indeed, a recent paper focused on families with preschool through adolescent children found that household disorder was more strongly predictive of family processes than was residential instability, suggesting that mothers' heightened psychological distress and parenting stress as well as less regulated family routines mediated associations between household disorder and children's functioning (Coley et al., 2012). Living with a lack of basic utilities such as water and heat, or with rodents and cockroaches, or in crime-infested neighborhoods with inadequate social controls may tax mothers' resources, limiting their ability to provide stable and supporting family processes for their children. Moreover, such contextual forces may directly influence children's health and development through increases in asthma and illnesses, heightened stress responses, and decreased regulation skills, in turn leading to poorer physical, emotional, and behavioral health.

The Role of Chaos in Infancy, Early, and Middle Childhood

In addition to assessing differences between domains of environmental chaos, a second goal of this research was to consider distinctions related to the developmental timing of chaos. Based upon infants' rapid development and immature physical and social systems, it was hypothesized that infants would be more susceptible to environmental insults than children in the early and middle childhood years (Bronfenbrenner & Evans, 2000; Shonkoff, 2010). To test this hypothesis, we compared associations between environmental chaos during infancy, early childhood, and middle childhood years and children's physical and mental health functioning.

This strategy allowed us to simultaneously control for prior and later chaotic experiences and compare the relative importance of environmental chaos across multiple periods of early development. Contrary to expectations, results suggested a recency effect, finding that environmental chaos during middle childhood was more consistently associated with child functioning than was earlier environmental chaos. Infant environmental disorder showed long-term associations with children's health in middle childhood, supporting the concern over long-term repercussions of children's early stressful environments for the emergence of health disparities later in life (Shonkoff, Boyce & McEwan, 2009). However, no other associations emerged between infant disorder or instability and children's early childhood health and development or middle childhood emotional and behavioral problems. In contrast, both environmental disorder and environmental instability during middle childhood were associated with heightened emotional and behavioral problems. This mirrors some prior research, such as work on relationship instability which has found that recent transitions in family structure were more consistently associated with low-income children's emotional and behavioral functioning than were transitions during infancy (Bachman et al., 2011). Given the difficulty of measuring children's development during infancy and early childhood in a valid and reliable manner (National Research Council and Institute of Medicine, 2000), however, we caution that these results may be affected by measurement issues, and encourage future research seeking to delineate the role of the developmental timing of environmental chaos.

In addition to the lack of evidence for the importance of early timing of environmental chaos, we also failed to find evidence that chaos interacted with children's biological risks to predict later functioning. Using an indicator of low birth weight, which other research has found to enhance children's susceptibility to environmental influences (Escalona, 1982; Kalmar &

Boronkai, 1991; Shonkoff, Boyce & McEwan, 2009), we failed to find any significant patterns of interactions with measures of environmental disorder and instability. It is important to note that the rate of low birth weight, reported retrospectively by mothers at 6% in this sample, was somewhat low in comparison to an 8% national rate in 2010, with rates of 14% among African American mothers, 7% for Hispanices, and 7 % for Whites (Martin et al., 2012). This lower than expected rate in our low-income ethnic minority sample might indicate measurement error and may have diminished the statistical power to detect interaction effects. Unfortunately, the data used in these analyses were lacking other measures of biological risks, leaving open the question of interactive effects for future research.

Modeling the Intensity of Early Chaos

A fourth primary goal of this study was to model effects of the intensity of environmental chaos. Although the ecobiodevelopmental model (Shonkoff, 2010; Shonkoff & Garner, 2012) argues that environmental forces that are recurring, sustained, and extensive will be more influential in affecting children's healthy development than more transitory and narrow forces, little research has explicitly tested this hypothesis. The first set of models in this paper assumed a linear relationship between environmental chaos in each developmental period and children's functioning, as has most prior research. To test the intensity hypothesis, in contrast, we coded environmental disorder and instability to capture both high levels of chaotic environments (by delineating each measure to capture individuals at least 1 SD above the mean), and sustained chaotic environments (by summing scores across all three waves). Findings in this arena were mixed. Models capturing the intensity and sustained nature of environmental chaos appeared to better predict children's functioning in the realms of developmental delays and physical health, with the intensity of environmental disorder predicting heightened developmental delays in early

childhood and worse physical health in middle childhood. These results may reflect an early indication of the embedding of environmental risks in young children. On the other hand, in relation to children's emotional and behavioral functioning, the recency of environmental chaos appeared to be as, if not more, important than the intensity of chaos. In particular, associations between environmental disorder and instability in middle childhood appeared somewhat more consistently associated with children's emotional, behavioral, and total problems at age 6 than did the cumulative measures of disorder and instability intensity. This suggests that environmental disorder and instability may have a more immediate, short-term impact on children's socioemotional functioning whereas cumulative, intense environmental disorder may have more lasting effects on children's health and physical development.

Limitations

In closing, it is important to acknowledge limitations in this research. Although the sample was randomly selected, it represents a particular population of disadvantaged urban families in three cities and cannot necessarily be generalized to other populations. Similarly, although we modeled prospective longitudinal data and adjusted for a range of child, family, and community covariates, our data were correlational and results cannot be construed as causal. There are also concerns about reporter and measurement bias, as many of the measures were derived from maternal reports, and others, such as low birth weight and children's health were derived from single-item reports. Moreover, the measures of environmental disorder captured particular snapshots in children's lives and may have missed proximal forces occurring between the survey waves. Beyond these limitations, this study adds to the extant literature base arguing that early environmental chaos, particularly environmental disorder, serves as a risk for low-income children's health and development.

Conclusions

The current study expands on recent work documenting the link between environmental chaos and child well-being by furthering our understanding of the processes underlying chaotic environments and focusing on the relative role of chaos during varying periods of child development. These findings suggest that chaos in the realms of both disorder and instability may have immediate, short-term, deleterious effects on emotional and behavioral functioning in middle childhood. However, there was also initial evidence suggesting a longer-term negative relationship between environmental disorder during infancy and children's health several years later during middle childhood, with effects potentially strengthened by extensive, longer-term exposure to disordered home and community environments.

By employing a within-group design focused on environmental chaos among low-income families in concentrated poverty urban neighborhoods, the present study yields important implications for program and policy development. Among other studies on families' chaotic living conditions, Vernon-Feagans and colleagues (2012) conducted one of the few prior studies utilizing a within-group design, with a sample limited to families living in rural environments. Given that experiences of environmental disorder and instability are most pervasive among families living in disadvantaged urban environments (Edin & Kefalas, 2005; Newman & Holupka, 2011; Schacter, 2001) and that low-income families are commonly targeted for policy and program interventions (Currie, 2006), it is valuable to explore the nuances of chaotic experiences within this population. Specifically, the findings in this study may help to inform home and center-based interventions, such as Early Head Start or home-visiting programs. Such programs may be improved by developing strategies to combat the stressful experiences for very young children that are conferred by environmental disorder. Similarly, federal and state

housing and neighborhood policies can seek levers to improve residential stability and the quality and safety of low-income families' contexts. In short, targeting treatment to specific developmental windows may help to buffer against the short- and long-term negative effects of environmental chaos for low-income families with young children.

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Table 1. *Sample Descriptives*

	M/%	SD
Child Functioning		
Early Childhood Functioning		
Poor Health	1.82	1.00
Developmental Delays	0.72	1.03
Middle Childhood Functioning		
Poor Health	1.81	0.94
Internalizing Problems	50.47	10.66
Externalizing Problems	52.49	10.39
Total Problems	51.16	11.05
Environmental Chaos		
Timing		
Infant Disorder	0.06	0.87
Infant Instability	0.89	1.35
Early Childhood Disorder	0.00	0.84
Early Childhood Instability	0.90	1.16
Middle Childhood Disorder	-0.03	0.77
Middle Childhood Instability	1.92	1.89
Intensity		
Cumulative Disorder W1-2	0.85	1.09
Cumulative InstabilityW1-2	0.54	0.69
Cumulative Disorder W1-3	1.23	1.37
Cumulative InstabilityW1-3	0.84	0.89
Covariates		
Child Age	12.69	6.92
Child Gender (Male)	0.48	0.49
Low Birth Weight	0.06	0.24
Maternal Employment	0.38	0.49
TANF Receipt	0.40	0.49
White	0.06	0.24
Black	0.41	0.49
Hispanic	0.53	0.50
Less than High School	0.34	0.47
High School Education	0.27	0.45
More than High School	0.37	0.49
Income to Needs	0.85	0.55
Boston	0.33	0.47
Chicago	0.33	0.47
San Antonio	0.33	0.47

Table 2. *Domains and Timing of Environmental Chaos Predicting Physical and Mental Health in Early and Middle Childhood*

	Early Childhood Functioning		Middle Childhood Functioning			
	Poor Health	Delays	Poor Health	Externalizing Problems	Internalizing Problems	Total Problems
	Coef (SE)	Coef (SE)	Coef (SE)	Coef (SE)	Coef (SE)	Coef (SE)
Main Effects Models						
Environmental Chaos						
Infant Disorder	0.16 (0.13)	0.06 (0.14)	0.12 (0.06)*	0.63 (1.05)	0.74 (1.40)	1.79 (1.14)
Infant Instability	-0.01 (0.06)	-0.01 (0.03)	0.02 (0.07)	0.29 (0.78)	0.14 (0.83)	0.28 (0.88)
Early Childhood Disorder	-0.11 (0.07)	0.18 (0.19)	0.09 (0.08)	0.71 (1.24)	0.46 (0.65)	0.34 (1.14)
Early Childhood Instability	0.01 (0.06)	0.01 (0.06)	0.05 (0.05)	-0.20 (0.53)	-0.40 (0.81)	-0.27 (0.58)
Middle Childhood Disorder			0.10 (0.10)	1.98 (1.06)+	2.50 (1.15)*	2.73 (1.18)*
Middle Childhood Instability			0.00 (0.03)	0.80 (0.31)**	0.48 (0.35)	0.66 (0.33)*
Covariates						
Child Age	0.00 (0.01)	0.00 (0.01)	-0.01 (0.01)	0.13 (0.11)	0.19 (0.19)	0.10 (0.18)
Child Gender (Male)	0.12 (0.19)	0.33 (0.14)*	0.01 (0.24)	1.16 (1.53)	-0.90 (1.45)	0.11 (1.05)
Low Birth Weight	0.53 (0.33)	0.58 (0.33)+	0.52 (0.21)*	1.74 (2.40)	0.41 (2.14)	1.87 (2.80)
Maternal Employment	-0.20 (0.19)	-0.06 (0.11)	0.10 (0.16)	-4.03 (2.39)+	-1.69 (2.07)	-3.17 (2.43)
TANF Receipt	-0.01 (0.15)	-0.03 (0.20)	-0.23 (0.12)*	1.34 (0.93)	-2.34 (0.84)**	-0.48 (0.98)
White	0.01 (0.31)	0.37 (0.40)	-0.09 (0.27)	-2.58 (3.56)	-2.71 (2.75)	-1.66 (3.36)
Black	0.13 (0.10)	0.24 (0.10)*	-0.12 (0.08)	-0.78 (1.54)	1.26 (1.22)	0.37 (1.21)
Less than High School	0.10 (0.10)	0.32 (0.17)+	0.04 (0.16)	0.65 (1.41)	2.14 (1.08)*	0.23 (1.13)
More than High School	0.07 (0.10)	0.22 (0.14)	-0.16 (0.11)	0.81 (1.57)	2.28 (1.78)	0.99 (0.95)
Income to Needs	-0.06 (0.15)	-0.16 (0.08)*	-0.17 (0.14)	1.68 (1.40)	-1.01 (1.29)	0.73 (1.33)
Boston	-0.13 (0.08)	0.24 (0.09)**	-0.06 (0.07)	-1.93 (0.99)+	-0.20 (1.55)	-0.53 (1.31)
San Antonio	-0.16 (0.10)+	-0.04 (0.07)	-0.03 (0.07)	-2.25 (1.05)*	-1.52 (1.77)	-0.99 (1.37)
Constant	1.94 (0.08)**	0.64 (0.06)**	1.87 (0.07)**	54.48 (0.75)**	50.9 (1.07)**	52.20 (0.90)**
Interaction Models						
Infant Disorder	0.16 (0.134)	0.08 (0.13)	0.12 (0.05)*	0.57 (1.05)	0.47 (1.36)	1.67 (1.17)
Infant Instability	-0.01 (0.07)	-0.01 (0.08)	0.02 (0.07)	0.26 (0.81)	0.14 (0.83)	0.26 (0.90)
Early Childhood Disorder	-0.09 (0.07)	0.14 (0.17)	0.11 (0.07)	0.88 (1.12)	0.75 (0.63)	0.57 (1.03)
Early Childhood Instability	0.00 (0.06)	0.02 (0.06)	0.06 (0.05)	-0.42 (0.63)	-0.58 (0.89)	-0.52 (0.73)
Middle Childhood Disorder			0.10 (0.11)	1.83 (1.02)+	2.55 (1.17)*	2.61 (1.17)*
Middle Childhood Instability			0.00 (0.03)	0.78 (0.36)*	0.44 (0.35)	0.66 (0.37)+
Low Birth Weight	0.21 (0.294)	0.58 (0.26)*	0.38 (0.28)	-0.99 (3.09)	-2.64 (2.63)	-1.59 (3.33)
Infant Disorder x LBW	0.58 (0.56)	1.27 (0.80)	0.23 (0.53)	0.49 (7.15)	-6.20 (8.43)	-0.29 (7.71)
Infant Instability x LBW	0.01 (0.28)	0.09 (0.36)	-0.10 (0.31)	-0.42 (3.32)	0.09 (3.09)	-0.20 (3.74)
Early Childhood Disorder x LBW	0.01 (0.47)	-1.36 (0.54)*	0.30 (0.47)	2.01 (5.90)	8.38 (7.07)	3.77 (6.13)
Early Childhood Instability x LBW	-0.21 (0.30)	-0.01 (0.33)	0.19 (0.36)	-3.14 (3.32)	-2.42 (3.13)	-3.72 (3.57)
Middle Childhood Disorder x LBW			0.15 (0.39)	-1.56 (4.39)	2.50 (4.03)	-0.35 (4.78)
Middle Childhood Instability x LBW			0.03 (0.21)	-0.23 (1.94)	-0.25 (1.84)	0.04 (2.11)

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$

Table 3. *Cumulative Environmental Chaos Predicting Children's Physical and Mental Health*

	Early Childhood Functioning		Middle Childhood Functioning			
	Poor Health	Delays	Poor Health	Externalizing Problems	Internalizing Problems	Total Problems
	Coef (SE)	Coef (SE)	Coef (SE)	Coef (SE)	Coef (SE)	Coef (SE)
Main Effects						
Environmental Chaos						
Disorder Intensity	0.03 (0.04)	0.21 (0.05)**	0.12 (0.04)**	0.93 (0.37)*	0.70 (0.78)	1.25 (0.71)+
Instability Intensity	0.03 (0.10)	0.06 (0.10)	0.07 (0.07)	1.58 (0.85)+	1.11 (0.87)	1.70 (0.99)+
Covariates						
Child Age	0.00 (0.01)	0.00 (0.01)	-0.01 (0.01)	0.11 (0.12)	0.16 (0.20)	0.07 (0.19)
Child Gender (Male)	0.08 (0.18)	0.33 (0.11)**	0.01 (0.26)	1.07 (1.50)	-0.87 (1.51)	-0.08 (0.99)
Low Birth Weight	0.55 (0.33)+	0.60 (0.31)+	0.57 (0.22)**	2.38 (2.67)	1.49 (2.15)	3.10 (3.01)
Maternal Employment	-0.16 (0.20)	-0.10 (0.12)	0.11 (0.17)	-4.37 (2.42)+	-1.75 (1.86)	-3.16 (2.24)
TANF Receipt	-0.01 (0.16)	-0.06 (0.18)	-0.22 (0.10)*	1.26 (0.87)	-2.28 (0.94)*	-0.46 (1.10)
White	-0.02 (0.31)	0.36 (0.40)	-0.08 (0.26)	-3.25 (3.64)	-3.18 (2.70)	-2.33 (3.49)
Black	0.12 (0.10)	0.24 (0.10)*	-0.13 (0.09)	-0.82 (1.69)	1.26 (1.38)	0.27 (1.38)
Less than High School	0.10 (0.12)	0.32 (0.16)*	0.07 (0.18)	0.75 (1.72)	2.33 (1.15)*	0.46 (1.50)
More than High School	0.07 (0.10)	0.22 (0.13)+	-0.16 (0.10)	0.99 (1.74)	2.63 (1.29)*	1.30 (1.03)
Income to Needs	-0.05 (0.14)	-0.16 (0.06)**	-0.15 (0.16)	1.45 (1.25)	-1.42 (1.47)	0.47 (1.48)
Boston	-0.15 (0.08)*	0.26 (0.09)**	-0.07 (0.07)	-2.34 (0.94)*	-0.70 (1.20)	-1.22 (1.11)
San Antonio	-0.21 (0.08)*	-0.01 (0.08)	-0.04 (0.07)	-2.35 (1.17)*	-1.76 (1.46)	-1.41 (1.29)
Constant	1.96 (0.07)**	0.62 (0.07)**	1.88 (0.07)**	54.66 (0.80)**	51.17 (0.82)**	52.61 (0.82)**
Interaction Models						
Disorder Intensity	0.03 (0.05)	0.20 (0.06)**	0.12 (0.04)**	0.88 (0.40)*	0.70 (0.79)	1.22 (0.74)+
Instability Intensity	0.02 (0.11)	0.06 (0.11)	0.07 (0.08)	1.28 (0.87)	1.00 (0.95)	1.43 (1.02)
Low Birth Weight	0.37 (0.26)	0.59 (0.25)*	0.36 (0.24)	1.08 (3.34)	-0.91 (2.99)	0.89 (3.54)
Disorder Intensity x LBW	0.27 (0.24)	-0.03 (0.44)	0.25 (0.15)+	-0.75 (1.45)	2.09 (1.88)	0.56 (1.71)
Instability Intensity x LBW	-0.29 (0.47)	0.03 (0.65)	-0.13 (0.36)	-4.24 (5.03)	-2.57 (4.89)	-4.31 (5.55)

Note. ** $p < 0.01$ * $p < 0.05$ + $p < 0.10$